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Analysis of Quality Control Strategy Using The Statistical Process Control (SPC) Method In The Mass Product Housing Project at Java Residence Cluster

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Statistical Process Control (SPC), quality, construction, java residence cluster, pareto analysis

ABSTRACT
The advancement of industrial activities requires high-performance management to achieve desired outcomes, particularly in complex projects such as construction. This study aims to analyze the application of the Statistical Process Control (SPC) method to improve product quality in the construction project of the Java Residence Cluster in Sidoarjo. Managing cost, time, and quality remains a significant challenge in construction projects. This research focuses on identifying and addressing complaints or defects in housing units that affect the quality of the project, using SPC as a quality control method. Data were collected from primary sources, specifically from the staff of PT. Mitra Usaha Konstruksi, as well as secondary data from relevant literature. The analysis shows that the application of SPC successfully reduced the number of complaints or defects from 5.95 complaints per unit in Cluster 1 Phase 3 to 3.12 complaints per unit in Cluster 2 Phase 1, with an effectiveness rate of 52.47%. Pareto analysis identified that the majority of complaints were related to doors, windows, and wall paint, suggesting that these areas should be prioritized for improvement in future construction projects. The study recommends the continued use of SPC to improve product quality and identify the root causes of defects to ensure compliance with the developer's quality targets.

Introduction

Advancements in industrial activities in various aspects require management that demonstrates high performance, precision, cost-effectiveness, integration, speed, accuracy, meticulousness, and security to achieve the desired outcomes (Pambudi, 2019). Managing activities with large-scale investments and a high level of complexity demands proven methods, high-quality resources, and the application of appropriate and up-to-date scientific knowledge. (Abrar Husen, 2009).

Companies need highly optimized performance (Sajiyo, Fathurrahman, L., Prasnowo, M.A., Rodli, A.F., Makki, 2019). One method developed to address these needs is Project Management. It is a management technique scientifically and intensively developed since the mid-20th century to handle specific activities in the form of projects. (Soeharto, 2001). Construction project management is a science and concept designed to execute and complete construction projects to ensure their timely, cost-efficient, and quality-compliant completion. The implementation of project management in construction work involves cost requirements, human resources, time management, quality, effective and efficient execution methods, and productivity levels of the project execution. (Ervianto, 2023).

To achieve mutual understanding between consumers and producers regarding the quality of products and services, standards regulating the specifications and criteria of the products and services produced by manufacturers are essential. Implementing projects in the construction service industry often faces significant challenges, particularly in managing cost, time, and quality, which are the primary objectives (Aristriyana, 2019). The success of these projects largely depends on how well these three objectives are achieved. Complex projects, such as apartment building developments, exhibit high levels of risk due to uncertainties in the construction process that can significantly impact the outcomes, including productivity, quality, and project budgets (Ningrum, 2019).

In the global market, consistency in quality is paramount, as product quality significantly influences a company’s current and future sales. If a company’s product quality is inconsistent, it adversely impacts production costs, leading to rework or even the destruction of substandard products (Sidartawan, 2014). Conversely, maintaining or improving quality enhances productivity, reduces production costs due to less rework, and increases sales. Companies do not intentionally design poor-quality products; such issues result from variations in the production process. At this stage, Statistical Process Control (SPC) is utilized to detect and control process variations (Septiana, 2019).

Previous findings that dynamic loads predominated in maximum pressure changes in boreholes (BH2) and (BH3), and were due to river discharge and tidal occurrence, respectively. The dynamic load of sediment in BH2 contributed more than in BH3, where it was almost nonexistent (Patriadi et al., 2021). This indicate that resolving a problem costs ten times more than preventing it. Such cost savings enable companies to lower prices, expand research and development, and simultaneously increase profits. Changes in product characteristics are merely reflections of input variations. Thus, the key to preventing defects in a product lies in monitoring and controlling all aspects of production (Mawadati, 2021).

By delivering high-quality goods or services, companies aim to attract consumers and meet their needs and desires. Effective quality control positively impacts the quality of products produced by companies (Supriyadi, 2022). The quality of a company's products is determined based on specific measures and characteristics. Quality control can be carried out using statistical tools such as Statistical Process Control (SPC) and Statistical Quality Control (SQC), where quality is managed from the start of production, throughout the production process, and until the final product is completed (Syahrullah, 2022).

Problem Formulation

Based on the background of the issue, the researcher identifies the problem formulation as follows: Can quality control using the Statistical Process Control (SPC) method improve product quality in the Cluster Java Residence construction project in Sidoarjo?

Research Objectives

The objective of this research is to enhance product quality using the Statistical Process Control (SPC) method in the Cluster Java Residence construction project in Sidoarjo.

Literature Review

Quality Management

Quality management is a series of managerial activities that include planning, organizing, coordinating, controlling, and evaluating quality. These activities are carried out by every management function within an organization to improve performance with a focus on the quality of work outcomes. According to ISO 9000 standards, quality is defined as the overall attributes of a product or service that affect its ability to meet specified requirements and satisfy established needs. Quality management consists of several stages, which are: (Solihudin & Kusumah, 2017)

a) Quality Planning

Quaity planning is the process of identifying quality standards relevant to the project being undertaken.

b) Quality Assurance

Implementing the planned activities to ensure that the project team has executed all necessary processes.

c) Quality Control

Monitoring the project's specific results to check whether they meet the agreed-upon relevant quality standards.

Data Collection for Statistical Process Control

● Data Collection Statistical Process Control

The data collection method used is sampling. This is because the researcher tests each item in a group, and most studies are based on random samples. The way the sample is taken from the population determines the view of the data, so the sample must be random. If it is not, an accurate picture of the population will not be obtained. With sampling, the researcher collects data from a number of items within a group and applies the results of this study to the entire group. When the researcher collects enough truly random samples, the research results will accurately reflect the group.

There are several factors to consider when developing a sampling plan. The goal of sampling is to obtain information that accurately represents the population being studied. First, identify what needs to be controlled, then decide on the sampling method to be used, how often it will be taken, where the samples will come from, and how many will represent the group.

● Statistical Process Control Analysis

The Statistical Process Control (SPC) method is used to prevent problems, as well as to detect and solve them. There are several tools that help define and resolve issues, as follows:

a) Pareto Diagram

The Pareto diagram is a combination of bar and line graphs that show the frequency of occurrences in a descending order. The bar graph in the Pareto diagram displays the frequency of an occurrence in decreasing order, while the line graph shows the cumulative total of these occurrences. This diagram follows the 80/20 principle, meaning 80% of the benefits come from 20% of the effort, and 80% of the problems are caused by 20% of the causes. Therefore, through this principle, a company can prioritize the most important issues to achieve maximum results. This diagram is used in data analysis to identify the most significant factors contributing to a problem.

b) Cause and Effect Diagram

The Cause and Effect diagram is a tool that helps identify, categorize, and display various potential causes of a problem or specific quality characteristics. This diagram shows the relationship between a problem and all the causal factors that influence that problem. This type of diagram is sometimes called the "Ishikawa" diagram after its inventor, Kaoru Ishikawa, or the "fishbone" diagram because it resembles the bones of a fish. The fishbone diagram can be used when we need to identify the root causes of a problem, categorize and analyze the interrelationships between different factors affecting the outcome, or analyze an existing issue to take appropriate action.

c) Control Chart

A control chart is a tool used graphically to monitor and evaluate whether an activity or process is within statistical quality control limits, so that problems can be solved to improve quality. A control chart shows changes in data over time but does not indicate the causes of deviations, although these deviations may be visible on the chart.

Effectiveness Analysis

The analysis tool used to measure the effectiveness of the CPM method in controlling time and the effectiveness of the SPC method in controlling quality in the Java Residence – Sidoarjo construction project with the "Mass Product" method. (Subagyo, 2004) explains that the effectiveness level can be calculated using the following effectiveness formula:

$$\text{Effectiveness} = \frac{\text{Actual Score}}{\text{Target}} \times 100\%$$

Here is the level of effectiveness achievement.

Table 1. Level of Effectiveness Achievement

Effectiveness Ratio	Level of Achievement
< 40%	Highly ineffective
40% - 59,9%	Ineffective
60% - 79,9%	Moderate effective
> 79,9%	Highly effective

Source: Litbang Depdagri (1991) from (Wilayah dan Sosial Budaya, 2022)

The urgency of this research lies in addressing the significant quality challenges in large-scale construction projects like the Java Residence Cluster, where defects and complaints undermine consumer satisfaction and increase costs due to rework. As the construction industry becomes more competitive, ensuring consistent product quality is vital for maintaining market trust and achieving operational efficiency. Effective quality control methods, such as Statistical Process Control (SPC), are crucial to minimize these issues and align project outcomes with client expectations.

The research gap exists in the limited application and analysis of SPC in Indonesian construction projects, particularly in the housing sector. While SPC has been proven effective in various industries globally, its integration into local construction practices has not been extensively studied. Additionally, there is a lack of focus on how tools like

Pareto analysis and control charts can identify and mitigate specific types of defects, thereby improving overall quality control processes in the construction domain.

The novelty of this study lies in its application of SPC to a mass housing project, demonstrating its potential to systematically reduce defects and prioritize improvements. By combining SPC with Pareto analysis and control charts, this research provides a unique approach to identifying root causes of defects and implementing targeted corrective actions, which has not been widely explored in Indonesian construction practices.

The study aims to evaluate the effectiveness of SPC in improving product quality in the Java Residence Cluster and to provide actionable insights for developers and contractors. The findings are expected to benefit stakeholders by offering a structured framework for quality management, reducing rework costs, and enhancing customer satisfaction. Furthermore, the research contributes to advancing quality control practices in Indonesia's construction industry, ensuring projects are delivered with higher precision and reliability.

Research Methods

Research Objective

This research is conducted to perform quality control on the construction of the Mass Product Cluster Java Residence, as well as to provide solutions to the construction stakeholders (Contractors) if the product quality does not meet the agreed standards

Research Time

The research was conducted from November 17 to December 7, 2024 which began in stages from field observations, secondary data collection, primary data creation, research, and secondary data analysis.

Data

The types of data in this study include primary data and secondary data. Primary data in this study was gathered directly from the staff of PT. Mitra Usaha Konstruksi (contractor) at the Java Residence Construction Project in Sidoarjo. The secondary data includes materials such as lecture notes, books, and articles on project and construction management, risk management, simulation, and other relevant sources.

Data Analysis Technique

a. Analysis using Control Chart with the following calculations needed:

- Percentage of Complains

$$P(Percentage\ of\ Complains) = \frac{Number\ per\ complaint}{Total\ number\ of\ complaints}$$

- Mean

$$P(Average\ Complaints) = \frac{Total\ complaints}{Number\ of\ households}$$

- Upper Control Limit

$$UCL = \vec{p} + 3\frac{\sqrt{P(1-p)}}{n}$$

- Upper Control Limit

$$LCL = \vec{p} - 3\frac{\sqrt{P(1-p)}}{n}$$

b. Analysis for identifying the most frequent damage and complaints using a Pareto Diagram.

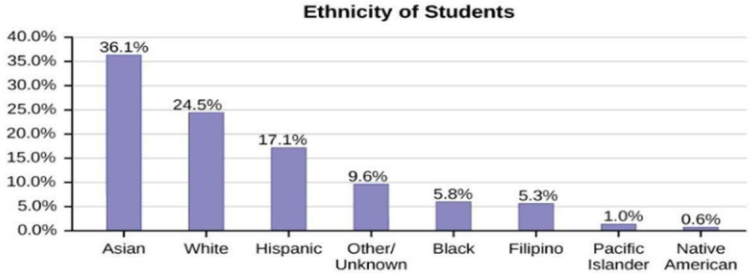


Figure 1. Ethnicity of Students

Effectiveness analysis using descriptive statistics. Descriptive statistics describe the main features of a data set in a meaningful way. Descriptive statistics utilize relatively simple methods, such as mean and variance. The results of descriptive statistical analysis are presented in the form of tables and graphs.

Results and Discussions

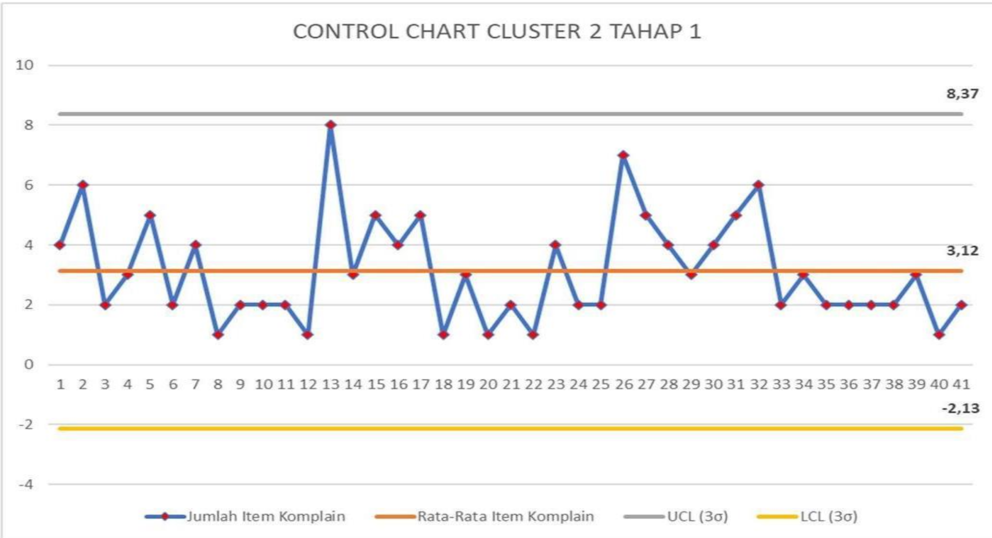
Control Chart Analysis

The Statistical Process Control method can reduce the average number of complaints or damages in housing units of Java Residence Cluster 2. Initially, in Cluster 1 Phase 3, the average was 5.95 complaints per housing unit, but now in Cluster 2 Phase 1, it has decreased to an average of 3.12 complaints per housing unit, as illustrated by the following control chart.

Table 2. Control Chart

Housing Number Unit	Number of Complaint Items	Percentage of Complaints	Average Number of Complaint Items	UCL (3σ)	LCL (3σ)
35	4	29%	3,12	8,37	- 2,13
37	6	43%	3,12	8,37	- 2,13
39	2	14%	3,12	8,37	- 2,13
50	3	21%	3,12	8,37	- 2,13
51	5	36%	3,12	8,37	- 2,13
56	2	14%	3,12	8,37	- 2,13
60	4	29%	3,12	8,37	- 2,13
62	1	7%	3,12	8,37	- 2,13
63	2	14%	3,12	8,37	- 2,13
65	2	14%	3,12	8,37	- 2,13
1	2	14%	3,12	8,37	- 2,13
5	1	7%	3,12	8,37	- 2,13
1	8	57%	3,12	8,37	- 2,13
2	3	21%	3,12	8,37	- 2,13
3	5	36%	3,12	8,37	- 2,13
3A	4	29%	3,12	8,37	- 2,13
5	5	36%	3,12	8,37	- 2,13
6	1	7%	3,12	8,37	- 2,13
7	3	21%	3,12	8,37	- 2,13
8	1	7%	3,12	8,37	- 2,13
9	2	14%	3,12	8,37	- 2,13

10	1	7%	3,12	8,37	-	2,13
2	4	29%	3,12	8,37	-	2,13
6	2	14%	3,12	8,37	-	2,13
8	2	14%	3,12	8,37	-	2,13
1	7	50%	3,12	8,37	-	2,13
3	5	36%	3,12	8,37	-	2,13
5	4	29%	3,12	8,37	-	2,13
7	3	21%	3,12	8,37	-	2,13
15	4	29%	3,12	8,37	-	2,13
17	5	36%	3,12	8,37	-	2,13
19	6	43%	3,12	8,37	-	2,13
10	2	14%	3,12	8,37	-	2,13
20	3	21%	3,12	8,37	-	2,13
1	2	14%	3,12	8,37	-	2,13
3	2	14%	3,12	8,37	-	2,13
7	2	14%	3,12	8,37	-	2,13
12	2	14%	3,12	8,37	-	2,13
17	3	21%	3,12	8,37	-	2,13
19	1	7%	3,12	8,37	-	2,13
3	2	14%	3,12	8,37	-	2,13



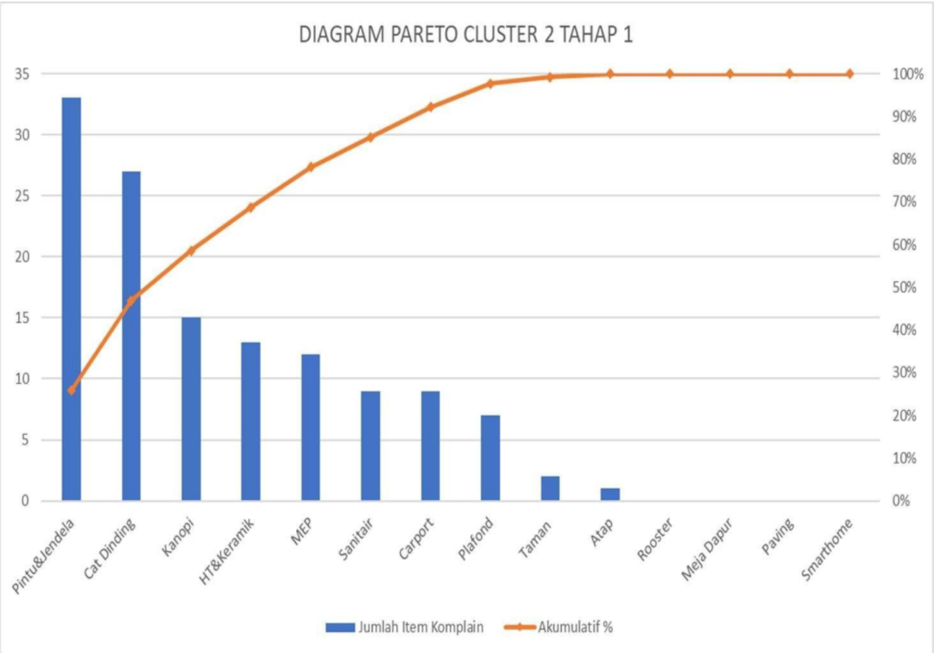
Based on the control chart, it can be seen that the control of Cluster 2 Phase 1 is already under control. However, the number of complaints or damages has not yet reached the target set by the Java Residence developer of 0.005 and is still within the normal limits.

Identifying the Types of Complaints

Next, the types of complaints caused by the construction process can be identified using a Pareto diagram. A Pareto diagram is used to identify and rank the types of complaints/damages (College, n.d.). Using this diagram, the most dominant types of complaints/damages can be determined as follows.

Table 3. Type of Complaints

Complaints by User	Number of Complaint Items	%	Accumulative %
Pintu&Jendela	33	25,78%	25,78%
Cat & Dinding	27	21,09%	46,88%
HT&Keramik	15	11,72%	58,59%
Sanitair	13	10,16%	68,75%
MEP	12	9,38%	78,13%
Plafond	9	7,03%	85,16%
Kanopi	9	7,03%	92,19%
Taman	7	5,47%	97,66%
Meja Dapur	2	1,56%	99,22%
Paving	1	0,78%	100,00%
Rooster	0	0,00%	100,00%
Carport	0	0,00%	100,00%
Smarthome	0	0,00%	100,00%
Atap	0	0,00%	100,00%
Total	**128**	**100%**	



Based on the results of the Pareto diagram above, it can be observed that approximately 50% of complaints/damages in the construction of housing units in Cluster 2 Phase 1 are dominated by complaints regarding doors & windows and wall paint. Therefore, improvements to these types of complaints or damages should be prioritized in the construction of future housing units to avoid similar complaints.

Effectiveness Analysis

From the data analysis results above, the effectiveness of using the Statistical Process Control method can also be evaluated as follows:

$$Effectiveness = \frac{Average\ number\ of\ complaints\ cluster\ 2\ phase\ 1}{Average\ number\ of\ complaints\ cluster\ 1\ phase\ 3} \times 100\%$$
$$= \frac{3{,}12}{5{,}95} \times 100\% = 52{,}47\%$$

Thus, it can be concluded that the use of the Statistical Process Control method can effectively reduce damages or complaints in housing units at Java Residence Cluster with an effectiveness rate of 52.47%.

Discussion

Based on the analysis conducted, the application of the Statistical Process Control (SPC) method in the construction project of the Java Residence Cluster in Sidoarjo has shown significant effectiveness in reducing the number of complaints or defects in the housing units. The use of SPC successfully reduced the number of complaints from 5.95 complaints per unit in Cluster 1 Phase 3 to 3.12 complaints per unit in Cluster 2 Phase 1, with an effectiveness rate of 52.47%. This demonstrates that the SPC method can be an effective tool for quality control in construction, a sector that often faces significant challenges in maintaining desired quality standards.

The Pareto analysis revealed that most of the complaints were related to doors and windows as well as wall paint. This finding provides clear guidance on which areas should be prioritized for improvement in future construction projects. By identifying the most common sources of defects, improvements can be more focused on these specific areas. Therefore, a more targeted approach to quality management will accelerate the process of addressing issues and prevent similar defects from occurring in the future.

One of the main advantages of implementing SPC in this project is its ability to identify the root causes of defects. With the data collected during SPC implementation, developers can more easily analyze and identify underlying issues such as material quality, work processes, or planning problems. Identifying these issues allows for more informed decision-making and more effective corrective actions, thus reducing the likelihood of similar issues arising in future projects.

Overall, this study shows that the use of SPC can have a positive impact on quality control in construction projects. This method not only improves product quality but also provides a strong foundation for developers to manage and monitor quality continuously. Therefore, it is recommended that SPC continues to be used in future development projects to ensure that quality standards are met and consumer expectations are fulfilled.

Furthermore, it is also important to note the significance of involving all stakeholders in the project, from planning and supervision to implementation, in the application of SPC. Effective coordination among these parties will ensure that the entire quality control process is executed optimally. In addition to SPC, other quality control methods, such as Six Sigma or Lean Construction, could also be integrated to support a more comprehensive and sustainable approach to quality management.

Conclusion

Based on the analysis and discussion in Chapter 4 regarding quality control in the construction of housing units at Java Residence Cluster, it can be concluded that the application of product quality control remains effectively managed. Statistical Process Control analysis indicates a significant decrease in the average number of damages or complaints by 52.47% during the construction of Cluster 2 Phase 1, reducing the average to 3.12 complaint items per housing unit. However, three major types of damages or complaints persist throughout the construction process, as identified through Pareto diagram analysis. These unresolved issues include defects related to doors and windows, wall paint, and HT and tiles, which continue to be observed in Cluster 2 Phase 1. This highlights the need for focused corrective measures to address these recurring problems and further enhance the quality of housing units.

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